LaTeX tutorial

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August 6, 2013

Abstract

This is an abstract. It should be about a paragraph long and should This is my edit summarize the results o the paper. I'm only going to use a few sentences in this example, but it should be enough to get the point across. Remote Change hahah Local Change Local Change 4

1 Apfelkuchen

Mehl 450 g. [1, S. 56] 3 Eier 4 Äpfel This is remote change 3 This sentence will be on the same line as the previous one. This sentence will contain an extra line break to signal the end of a paragraph.

This is a second paragraph. I'm not going to write that much here, as it is for illustration purposes only. Anyway, I'll show you the subsection construct next.

1.1 Subsection example

The double backslash delimiter adds an extra line break to the end of a line.
This is a new line, but still technically in the same paragraph as the previous one due to there not being two line breaks in the text editor after the first line.
This is going to be in a new paragraph. However, since I didn't add an extra line end at the end of the previous paragraph, it will look like a new line in the same paragraph.

Adding extra line breaks in the editor will not add extra line breaks in your document.

1.2 Lists

Lists can be made with the itemize or enumerate environments. These lists can be nested. Here is an example of an itemized list. There shouldn't be much to comment about in this case, as the syntax is both limited and straightforward.

- First item...
- Second item...
- Third item...
- Fourth item...
- etc...

Here is an example of an enumerated list. It's got basically all of the same syntax as the first list, but just uses a different environment.

1. Pancakes
2. Waffles
3. French toast
4. Bacon
5. Hash browns

It's also possible to make lists where you choose the labels. To do this, use the description environment as such.

First
: This is the first item.

Second
: This is the second item.

Third
: This is the third item.

It's not required to have a line break or anything after each customized list beginning. Here is another way to do the same list.

First This is the first item.

Second This is the second item.

Third This is the third item.

2 Citations

Citing your sources is important, so I will talk about it now and include citations throughout the rest of the tutorial. Basically, what to do is to make a list of references in an external file with a .bib extension. The one I am using for this tutorial will be called reference_list.bib. I probably won't comment it much, but it has an easy to follow and logical structure. Now, the addition of this extra file adds an extra step to the compilation process. When compiling a latex document in a terminal, the process goes as follows:

```
$ pdflatex filename.tex
$ bibtex filename.aux
$ pdflatex filename.tex
$ pdflatex filename.tex
```

When using a GUI application like TeXmaker, there should be compile buttons for both (pdf)latex and bibtex. The compilation process will use the same order as the process in the terminal. First, compile the latex document. Next, use bibtex. After that, compile the latex document twice and you should be good to go.

3 Mathematics typesetting

There are way too many math symbols to go through here, but there are plenty of reference tables online. One general rule is that Greek letters are created by typing out the name. For capital Greek letters, capitalize the name. Example: α, β, γ, Δ, Ψ, ψ, χ. Exponents and subscripts are done by ând _, respectively. For exponents/subscripts that are more than one character, brackets are required. Example: x^2, x_0, A^i_j, e^{-x^2}, X^{ab}_{cd}. Square root is $\sqrt{x}$, and functions like sine, cosine, and tangent get their own commands. Example: $\sin(x)$, $\exp(x)$, $\arctan(x)$. You could also use brackets around the arguments of those functions if you like.

3.1 In-line math mode

I'll start this section out by talking about inserting math typesetting into the middle of sentences, like this: $E = mc^2$. As we will see in a second, not all of the display options you might want are not going to be available by default. For example, here are two examples of the syntax for fractions: $\frac{a}{b+c}$ and $\frac{a}{b+c}$. The second version is also equivalent to this: $\frac{a}{b+c}$. Some math functions have a 'displaystyle' option, whereas other are the same either in an in-sentence math equation or as an equation in an equation environment, which I will go over next. The main types of math typesetting where you might need to use the displaystyle option are fractions, sums, and integrals. There might be more, but I don't have them in my memory right now, so you will have to RTFM.

Another thing to note about the in-line math syntax is that $it\ makes\ all\ letters\ italicized$, although you have to use escape sequences for spaces. This probably isn't the best way to do things and I will discuss other ways later. However, for single words, it is probably fine.

3.2 Math environments

I'm now about to show examples of various math environments. We will start with the equation environment. For an example that uses a variety of math syntax and symbols, I will use the Schrödinger equation [2]. To get more examples like the umlaut syntax I just used, search for latex special characters. This environment gives numbered equations. I can even reference Equation (1) before I have even wrote it, although the reference will show up as a couple of question marks on the first compile. Compile it again to get the equation number.

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi + V\Psi \tag{1}$$

Next, I will demonstrate an equation without numbering. The name of the environment is called *displaymath*. I will demo it with the Biot-Savart Law from electromagnetism [3]. Hopefully, the equations that I use can help you out with learning various math syntax.

$$\vec{B} = \frac{\mu_0}{4\pi}\int\frac{I\vec{dl}\times\hat{r}}{r^2}$$

Another great resource for learning latex syntax for math is wikipedia. Just find a page with equations and hit the edit button to view the latex source.

3.3 Arrays and grouped equations

I'll give off some demos of arrays and grouped equations in latex. I should warn that I rarely use this feature, but it is worth knowing. This feature can get complicated fast, so I'll start with just a matrix and work up to matrix equations.

Here is the identity matrix:

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

There are other matrix environments available to use. Here is the identity matrix with one of these environments:

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Here are the Lorentz transformations [4] for motion in the x direction, in matrix form ($c = 1$).

$$\begin{bmatrix} t\prime \\ x\prime \\ y\prime \\ z\prime \end{bmatrix} = \begin{bmatrix} \gamma & -\beta\gamma & 0 & 0 \\ -\beta\gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} t \\ x \\ y \\ z \end{bmatrix}$$

Here is an example of a system of equations. Note that the column arrangement is different from the first matrix.

$$\begin{aligned} 2x + 3y + 4z &= 0 \\ 3x - 8y - 6z &= 0 \\ 5x + 7y - 7z &= 0 \end{aligned}$$

Here is the same thing, but with a bracket on the left. In general, the array environment is more flexible and customizable than the matrix environment, but both should work well.

$$\left\{ \begin{aligned} 2x + 3y + 4z &= 0 \\ 3x - 8y - 6z &= 0 \\ 5x + 7y - 7z &= 0 \end{aligned} \right.$$

There is also an environment called *cases*, which can be useful for piecewise equations. Here is an example. Like always, the ampersand simple is used as a delimiter to distinguish sections from one another.

$$f(x) = \begin{cases} x^2, & if x \geq 0 \\ -x, & if x < 0 \end{cases}$$

4 Figures and tables

You are bound to eventually have a plot in your latex document. Tables might also be necessary as well. The first sections that I will show are "floating" figures. That means that latex will automatically place the figure at the beginning of a page or wherever it sees fit. I'll later show how to disable this feature. Tables made using the tabular environment don't float.

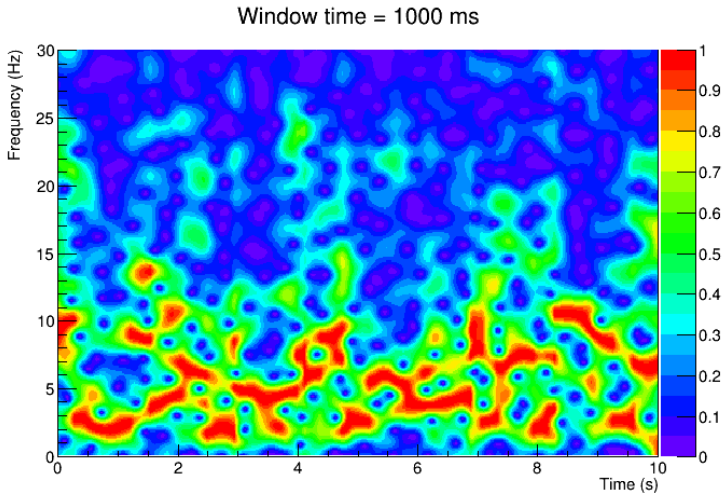

Figure 1: Spectrogram of an EEG reading computed using the Short-Time Fourier Transform.

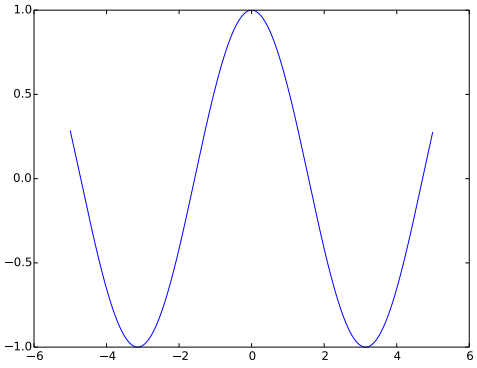

Figure 2: $\cos(x)$

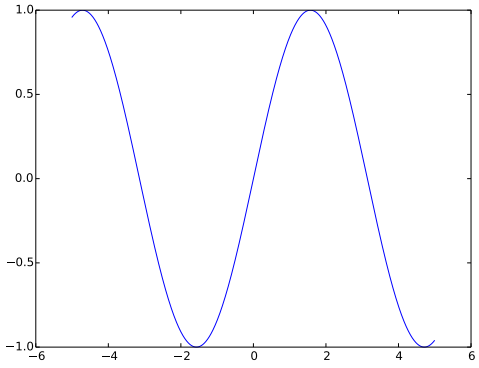

Figure 3: $\sin(x)$

4.1 Figures

To embed a figure, use the figure environment. It is required that you have the graphicx package set in your preamble. Here is an example of a figure, using a plot from the final project of my basic semiconductor circuits class (See Figure 1). LaTeX will automatically place this figure somewhere.

That's a simple example of a figure and it should be sufficient for most applications. Next is an example of two side-by-side plots. The *minipage* environment will be used to achieve this (See Figures 2 and 3). Captions and labels can also be placed outside of the minipage environments (See Figure 4) It might be possible to put captions in both places, but I have never tried that.

LaTeX supports many image types and you can even embed PDF's in LaTeX documents as figures. It should be mentioned that the size of am image is one of the determining factors of the size of the output file. For example, if a 25 MB jpeg image gets embedded into a LaTeX document, the output document will be over 25 MB. Basically, images should be resized to the absolute minimum size necessary before being included in LaTeX documents to avoid creating incredibly large output

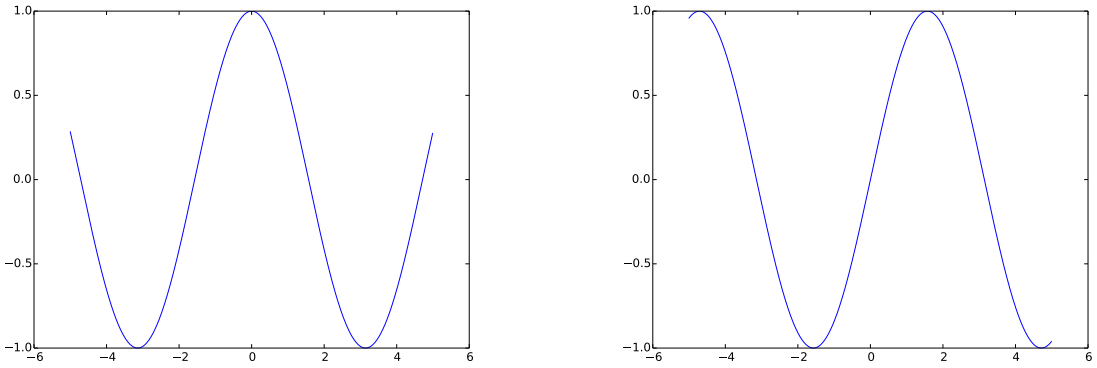

Figure 4: $\cos(x)$ and $\sin(x)$

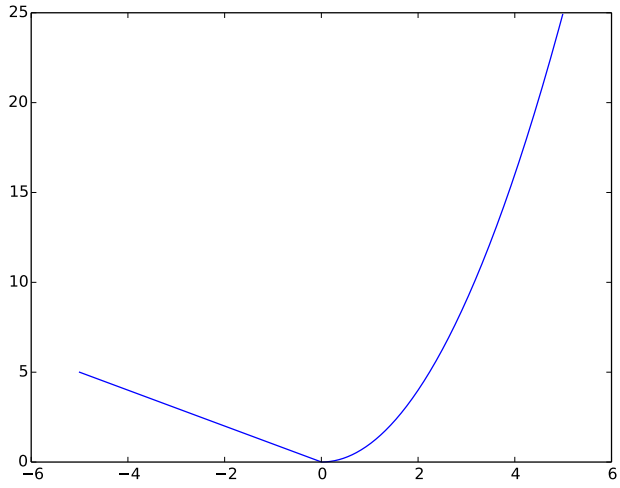

Figure 5: PDF format

files. Nobody wants to have to deal with a +100 MB file containing a bunch of images. Size that stuff down.

Another stylistic consideration to make is to use pdf instead of png for plots when possible. The reason for this is that most of the time, when saving plots to pdf, the output is lossless. When saving to png format, the output is always lossy and you can tell the difference by looking at a png plot versus a pdf plot (See Figures 5 and 6). Of course, there are some exceptions. If a PDF plot is large or LaTeX is having trouble embed it, then using png instead of pdf is an alright choice to make (See Figure 1). This convention is purely stylistic.

4.2 Tables

I'll give an example of a table. Like arrays, one must specify the alignment of the columns. However, one can also choose to have vertical lines in between columns in the alignment. The syntax

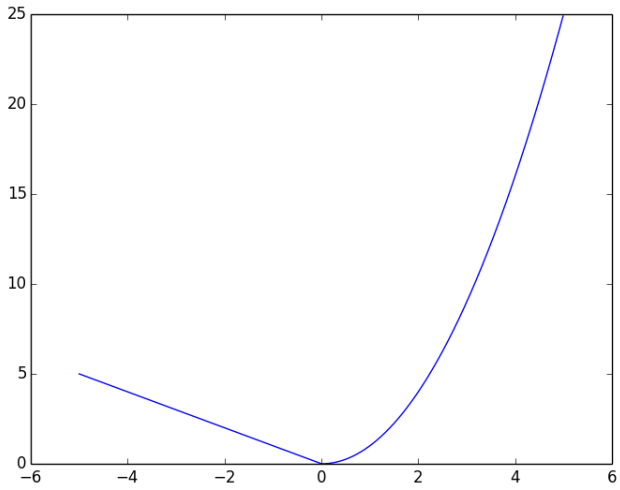

Figure 6: PNG format

is very similar to arrays and matrices, so I won't say that much about tables here.

Col. 1	Col. 2	Col. 3
0.234	cheesecake	234.2
OpenBSD	3.14	2.718
134.1324	52345.52	snowboard

4.3 Non-floating figures

Sometimes the figure floating of LaTeX can be annoying and inconvenient, so it needs to be disabled. Here is how to do that (Figure 7).

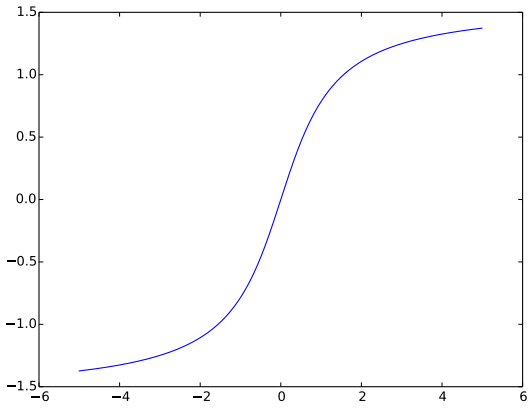

Figure 7: $\tan^{-1}(x)$

5 Conclusion

That's all for now. Have fun!

References

[1] *Wissens- und Technologietransfer: Analysen, Konzepte, Instrumente*. Bibliotheks- und Informationssystem der Univ, Oldenburg, 2005.

[2] D. Griffiths. *Introduction to Quantum Mechanics*. 1995.

[3] D. Griffiths. *Introduction to Electrodynamics*. 1999.

[4] Wikipedia. Lorentz transformation, 2013. https://en.wikipedia.org/wiki/Lorentz_transformation.